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AUTHOR Dotson, Charles O.
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ABSTRACT

This research study determined the relative importance of various basic motor ability traits possessed by the learner in the process of acquiring neuromuscular skills. Fifty-two university students practiced two novel skills (ball toss and fli-back paddle ball) 5 days per week for 2 weeks. Prior to beginning practice, each subject was measured on 26 basic motor ability items. Factor analysis was employed to isolate basic factors underlying each practice sequence and the gross motor performance traits. Ten stable factors were isolated, including two that described practice for the novel skills and eight that involved gross motor performance. Comparisons of the factor loadings among practice stages for each novel skill across the eight motor performance factors suggested the following conclusions: a) no relationship existed between gross motor factors and performance on the fli-back paddle ball skill; b) gross motor factors were related to performance on the ball toss skill during early, but not late, stages of practice; c) different gross motor factors related to performance on the ball toss skill as practice continued; and d) performance on the ball toss skill should be assessed only after several practice periods to prevent score comparisons. (Author/JA)

Novel Skill Learning and Gross Motor Performance Correlates

Charles O. Dotson[1]
University of Maryland
College of Physical Education,
Recreation, and Health
Department of Physical Education
College Park, Maryland 20742

Introduction

The purpose of this research was to determine the relative importance of various basic motor ability traits possessed by the learner in the process of acquiring neuromuscular skills. In particular, the study attempted to determine the degree to which performance on certain novel motor tasks at various stages of practice are free of influence from certain rather permanent gross motor ability traits.

Such studies are rare in the literature. The few that have been conducted involved complex coordination tasks of a highly specialized nature (e.g. making complex adjustments of an airplane stick and rudder in response to visual signal patterns), (9) related printed test performance and psychomotor test performance, (26) or utilized basic abilities highly loaded with non-motor factors (e.g. numerical operations, speed of identification, visual pursuits, and spatial orientation). (29) (10) (15) (4)

Many of these studies have provided theoretical principles which have been generalized to include gross motor skill learning of interest to the physical educator. The generalizations must be made with caution until further evidence on motor skills upholds or refutes these principles.

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Determining the factor structures of motor skills acquisition is important for a number of reasons. The determination that different abilities are important in the various phases of learning a skill discourages attempts to predict future success in terms of initial performance. If the basic hypothesis holds true for a given motor skill the need for criterion analyses of more advanced levels of proficiency is emphasized. Further, establishing the tenability of the basic hypothesis would have implications for test development in the motor skill area investigated. For example, factor structure changes with practice suggest that abilities contributing variance at different stages of motor skill performance must be defined in order to permit specification of how much practice to allow to reach the stage of performance at which it would be most desirable to score the test battery. This stage of performance would be the point the factor loadings of the battery items are at a maximum and other items of lesser importance to the criterion score are at a minimum. In view of the low validity coefficients reported for most sports skill tests, this proposed approach is quite important in the development of useful sport skill test batteries.(21)(18)(2)

Method of Procedure

Fifty-two male university students practiced two novel skills involving eye-hand coordination. The two skills are described below. Selection of the skills was based on the criterion of ease of scoring and general novelty to a large group of individuals.

Ball Toss

A eye-hand coordination task which possesses a negative acceleration learning curve.(28) Subjects sat in front of a table and attempted to bounce a table tennis ball from the table into a cylindrical target.

The target was constructed of tin sheeting and situated four feet from the front edge of the table. There were three target boundaries or openings with radii of 1 1/4, 3 3/4, and 6 1/4 inches. Except for those tosses which missed the apparatus, trials were scored one, three, or five points accumulated in 25 tosses.

Fli-Back Paddle Ball

A eye-hand coordination task which possesses a positive acceleration learning curve.[28] Equipment utilized was a paddle racket with a 30 inch rubber string attached at one end to the racket and to a one inch diameter rubber ball at the other end. Subjects attempted to hit the ball consequently as many time as possible. The score per practice session was the total number of successive hits summed over four trials. One trial was defined as one in which subject successfully hit the ball at least three times in succession.

The two skills described were practiced five days per week for two weeks, giving a total of ten practice sessions. In each case the procedure followed was selected to permit acquisition curves of previous studies to be compared with results obtained in the present research.

Prior to beginning practice on the two motor skills each subject was measured on twenty-six basic motor ability items. Selection of the motor abilities were made on the basis of their consistent appearance in previous factor analytic studies. Specifically the works of Fleishman,[8] Ismail and Cowell,[17] and Cumbee[6] were relied heavily upon. The list given below provides the factor involved and each test measuring that specific factor.

Explosive Strength-General
1. Figure 8 Duck

Explosive Strength-Legs
2. Standing Broad Jump
3. Vertical Jump

Static Strength
4. Hand Grip
5. Arm-Pull Dynamometer

Dynamic Strength
6. Pull-ups (limit)
7. Pull-ups (20 sec.)

Extend Flexibility
8. Twist and Touch
9. Toe Touching

Dynamic Flexibility
10. Lateral Bend
11. Bend, Twist, and Touch

Gross Body Equilibrium
12. Two Foot Cross Balance-Eyes Closed
13. One Foot Lengthwise Balance-Eyes Closed

Kinesthetic Sense
14. Arm Position right
15. Arm Position left

Balance-Visual Cues
16. One Foot Lengthwise Balance - Eyes Open
17. One Foot Cross Balance - Eyes Open
18. Ball Balance

Speed of Limb Movement
19. Plate Tapping
20. Two Foot Tapping

Gross Body Coordination
21. Cable Jump
22. Soccer Dribble
23. Dodge Run
24. Bar Snap

Reaction and Movement Time
25. Visual Reaction Time
26. Auditory Reaction Time
27. Movement Time

Multilimb Coordination
28. Complex Coordination Test
29. Two Hand Coordination Test

Control Precision
30. Discrimination Reaction Time
31. Unidimensional Matching

Response Orientation
32. Discrimination Reaction Time
33. Direction Control

Manual Dexterity
34. Minnesota Rate of Manipulation-Placing
35. Minnesota Rate of Manipulation-Turning

Detailed descriptions for each of the above test items may be found in Fleishman.(8)

Statistical treatment of the data involved computing intercorrelations among the practice sessions for each motor skill and the thirty-five basic motor abilities. Taking each motor skill separately along with the basic motor abilities gave four 35 x 35 intercorrelation matrices. Each intercorrelation matrix was subjected to factor analysis to determine the relative importance of the various basic motor abilities throughout the learning process.

Factor analysis is a multivariate statistical technique which permits intercorrelations of a number of variables to be objectively categorized into "clusters" of test scores such that tests within clusters are highly related and tests between clusters are minimally related. Thus factor analysis permits a correlation matrix to be reduced to a factor matrix of minimum dimension which in some reasonable sense reproduces the original correlations. The specific methodology used for the present investigation was Hotellings's Principal-Component Analysis (16) as a preliminary solution. This analysis is a multivariate generalization of the least squares solutions used in regression analysis. Two additional preliminary solutions also were obtained utilizing alternate procedures suggested by Rao (25) and Kaiser and Caffrey (20). These were respectively Canonical Factor Analysis and Alpha Factor Analysis. The reason for the three preliminary solutions

was that there does not exist universal agreement as to which approach is best. Although it should be noted that generally only minor differences exist. However, to insure that derived factors extracted for a given analysis are not a function of the methodology utilized, only those factors which are logically sound across all three solutions were considered. For each preliminary solution, orthogonal rotation of the factor matrix was achieved utilizing Kaiser's Varimax Criterion (19). Orthogonal rotation was necessary for interpreting the nature of factors extracted by the different preliminary solutions. The results permitted stable factor structures of each motor skill to be characterized.

Results and Discussion

Intercorrelation matrix indentifying relationships among the test variables included in Tables 1 - 5. Rotated factor loadings for all factor analysis results are presented in Tables 6 - 9.

Factor Identification.

In this section the rotated factor loadings for each factor isolated for each novel skill will be presented and discussed. Emphasis is placed upon identifying each factor as a robust trait. Generally, only loadings of .30 and higher are included in the body of the paper for discussion.

FACTOR Ia

No.	Variable	8F Loading	10F Loading
27	Fli-back Day 1	.95	.95
28	Fli-back Day 2	.98	.98
29	Fli-back Day 3	.96	.96
30	Fli-back Day 4	.98	.98
31	Fli-back Day 5	.98	.98
32	Fli-back Day 6	.98	.98
33	Fli-back Day 7	.98	.98
34	Fli-back Day 8	.97	.97
35	Fli-back Day 9	.99	.99
36	Fli-back Day 10	.97	.97

Factor one(a) is characterized in both solutions by extremely high loadings for the Fli-back paddle ball scores for all 10 practice sessions. The lowest loading of .95 is associated with the first practice session and the highest loading is associated with the ninth practice session. The loadings, however, follow no trend suggesting the relationship between sessions increases as practice continues. Since the loadings are near one from the first session

this suggest that one's success in performing this novel eye and hand coordination task can be predicted on the basis of his intial performance. The large percent contribution of this factor indicates that a major part of the total factor structure is unique to the skill. The decision to rotate eight or ten factors had no effect upon the structure of this factor. This factor is thus readily defined as Eye-hand Coordination Test Specific.

FACTOR Ib

No.	Variable	13F Loading	8F Loading
27	Ping-pong Day 1	.06	.15
28	Ping-pong Day 2	.23	.23
29	Ping-pong Day 3	.53	.51
30	Ping-pong Day 4	.46	.43
31	Ping-pong Day 5	.73	.66
32	Ping-pong Day 6	.48	.52
33	Ping-pong Day 7	.69	.66
34	Ping-pong Day 8	.62	.65
35	Ping-pong Day 9	.88	.89
36	Ping-pong Day 10	.79	.80

Factor one(b) has high loadings associated with variables defining performance on the Ping-pong ball toss skill. It may be noted that the factor loadings for the ten practice sessions increase from the first to the tenth sessions. This suggest that the skill is not highly specific as was the case with the Fli-back paddle ball test. Thus, this factor is defined as Object Projection for Accuracy. Unlike Factor one(a), performance on this factor would not be reliably assessed utilizing early practice session performance scores. The fact that the two novel skills differ in this respect permits us to compare the two factor structures during the learning process.

FACTOR II

No.	Variable	FBPB 8F	PPBT 8F	FBPB 10F	PPBT 13F
20	One-foot Tapping	.94	-.93	.93	-.91
16	Movement Time	.91	-.91	.92	-.93
15	Visual Reaction Time	.90	-.89	.90	-.91
17	Plate Tapping	.85	-.83	.84	-.78
13	Hand Grip	-.64	.67	-.66	.68
14	Ball Balance	.61	-.65	.63	-.64
18	Two-foot Tapping	.48	-.52	.48	-.39
21	Block Transfer	-.43	.42	-.42	.30
22	Kinesthetic Sense	.42	-.40	.38	-.42
11	Vertical Jump	.29	-.25	.28	-.27
	% Cont.	13.5%	13.5%		

Factor II is defined by a number of items requiring speed of limb movement. This is true of three of the four highest loading variables with reaction time accounting for the fourth. In addition, two other speed of limb movement variables exhibit moderate loadings for this factor. The remaining variables involve ability traits which are auxiliary factors of the speed of limb movement task. For example, hand grip, a measure of static strength, would logically correlate with strength required to overcome inertia of limb to perform the movement required. Since speed of limb movement tests generally require the movement of the limb over a short distance the predominant force required to execute the movement is static in nature, thus, explaining the static strength measure's (hand grip) loading for this factor. The high moderate loading for Ball balance indicates that this factor also involves speed of movement to perform a specific task. It seems clear that this factor may be defined as Specified Speed of Movement. The 13.5 percent contribution of

this factor to the total factor structure suggest that speed of movement is a dominant trait required to execute the ability tests included in the total variable space. Like the first factor the decision to rotate eight or ten factors had no effect upon the parsomonius structure of this factor. In addition, the inclusion of the basis motor ability items with each set of novel skill learning scores had no influence upon the simple structure of this factor. The results suggest this factor is quite robust.

FACTOR III

No.	Variable	FBPB 8F	PPBT 8F	FBPB 10F	PPBT 10F
9	Pull-ups Timed	.91	.89	.93	.88
8	Pull-ups Limit	.88	.88	.90	.88
12	Arm Pull	.59	.51	.55	.50
25	1 ft. Lengthwise Balance Eyes Closed	.49	.34	.43	.27
10	Standing Broad Jump	.43	.60	.47	.64
11	Vertical Jump	.36	.50	.40	.54
3	Twist & Touch	-.32	-.30	-.29	-.29

This factor is heavily loaded with general strength items. The highest loading (.91 & .93) is associated with an explosive strength measure with the second highest loading associated with a test requiring gross strength, explosive strength and endurance. It is well known that the three are moderate to highly related (10). These two items are followed by the static strength measure identified as arm pull. The remaining items involve balance, a task greatly facilitated by a high static strength component, explosive power, as measured by standing broad jump and vertical jump, and flexibility a physiologically limiting component to general strength measures.

This factor is best represented by items common to three different factors isolated by Fleishman, the structure of which has been questioned by a number of previous studies (Harris and Liba, Harris, Safrit, Liba, and Jackson). All suggested at least five factors were present. This study does not include all of the items included in the original Fleishman study and was not intended to study the stability of his original factors. The basic purpose of this study, however, requires that definite stable factors be present as reference traits to characterize the learning curves for the novel skill studied. Since the items common to the Fleishman study all cluster in only one factor in this study the results only add to the dilemma. The factor isolated in the present study, however, is the most reliable of those isolated by this and previous strength studies since the present studies factor is general. The relationship of this factor with the skill learning curves will then be at least as high as the correlations which will be presented below. With these observations in mind we may define this factor as General Strength With Explosive Components Emphasized.

FACTOR IV

No.	Variable	FBPB 8F	PPBT 8F	FBPB 10F	PPBT 13F
19	Lateral Bend	-.80	.73	-.81	.84
12	Arm Pull	-.53	.51	-.59	.42
14	Ball Balance	-.46	.42	-.43	.46
25	1-ft. Balance-Eyes Closed	-.36	.44	-.41	.35
33	Ping-pong B.T. Practice 7		.45		.29
34	Ping-pong B.T. Practice 8		-.33		-.21
18	Two-foot Tapping				.33

This factor has loadings associated with a diversity of items. On first impression one is inclined to conclude that the factor is not stable enough to define. To be sure this possibility cannot be completely ruled out. However, considering the mechanics involved in each task represented and the kinetoenergetics involved does provide for a tentative definition of the factor. Each item involves some degree of flexibility either as the dominant ability trait as in the Lateral Bend item or as a limiting factor as in the strength measure Arm Pull. This latter characteristic holds for both maximum strength as in the Arm Pull item or a sub-maximal strength trait required in the balancing tasks of Ball Balance and One-foot Lengthwise Balance eyes closed. That is, in the latter involvement for flexibility, it is well known that flexibility and strength are related since maximum strength can be exerted 1.2 times resting length with anatomical limitations usually representing this 1.2 times factor. Thus, loss of flexibility reduces usable force. This also holds for any percentage of strength exerted. Thus, greater control can be maintained over a given set of muscles when the number of muscle fibers required to execute the task is small. Flexibility provides this element for the Ball Balance and One-foot Lengthwise Balance eyes closed. Thus, Flexibility as a Limiting Factor to Task Performance is the definition given to this factor. It is interesting to note that the ping-pong ball toss practice sessions 7 and 8 load high enough to be included in the list of items to be used in defining this factor. Further discussion of this association is made later in the report.

The stability of this factor held across the four analysis performed. It did, however, shift in importance in the factor structure when the ping-pong ball toss practice sessions were included in the analysis. The shift was from fourth to sixth for both the eight factor and 13 factor rotation.

FACTOR V

No.	Variable	FB 8F	PP 8F	FB 10F	PP 13F
7	Bar Snap	-.74	-.73	-.81	-.47
10	Standing Broad Jump	-.70	-.50	-.69	-.28
11	Vertical Jump	-.62	-.46	-.50	-.33
25	1-ft. Balance Eyes Closed	.30	.31	.32	.21
1	Dodge Run	.28	.26	.35	.05
27	Ping-pong B.T. Practice 1		-.70		-.84
28	Ping-pong B.T. Practice 2		-.65		-.78
22	Kinesthetic Sense				.28

The variables loading high on this factor involve projecting the body with power. This is true for the first three factor solutions presented above. The top loading of the body projection variables is challenged by the Ping-pong Ball Toss Practice 1 and 2 for the third solution involving eight rotated factors. These latter measures surpass the body projection variable loadings when thirteen factors were rotated. It is possible that this factor is multi-dimensional. Evidence to support this is seen from the latter two factor solutions involving the Ping-pong Ball Toss measure. In these solutions the loadings for the body projection measure decrease in magnitude and exhibit significant loadings on other factors. In view of the fact that the factor is stable with respect to the Fli-back Paddle Ball this factor is defined as Body Projection with Power.

It is interesting to note that when the Ping-pong Ball Toss practice scores are analyzed with the twenty-six reference variables the factor structure does not separate body projection and object projection variables into two factors. Disagreement exist in the professional literature concerning the separation of these factors. It would appear that in each case body projection and object projection variables are factorially complex.

FACTOR VI

No.					
4	Toe Touching	.82	.64	.84	.86
5	Cable Jump	.61	.51	.19	.08
22	Kinesthetic Sence	.41	.35	.32	.35
18	Two-foot Tapping	.36	.33	.48	.20
23	1-ft. Lengthwise Balance Eyes Open	-.24	-.47	-.00	-.13
29	Ping-pong B.T. Practice 3		.47		.09
2	Figure-8 Duck	.23	.13	.19	.34
25	1-ft. Lengthwise Balance Eyes Closed	-.11	-.00	-.21	-.35
30	Ping-pong B.T. Practice 4		-.18		-.48
	% Contribution	4.76	4.40	5.06	4.75

This factor is highly loaded with variables involving full range flexibility or task with full range flexibility serving as a limiting factor. Thus, this factor may be defined as Extend Flexibility. The factor does not prove stable across all four factor solutions. It is best defined for the solutions rotating eight factors. The eigen criterion rotation, which permitted Ten and Thirteen factors respectively to rotate, shows a compressed loading for those items where full range flexibility is a limiting factor. Otherwise the flexibility trait remains intact. This is important and suggests a more stable factor than might otherwise be the case. In addition,

a shift from Eight to Thirteen factors exhibits a drastic shift in loading for the two practice sessions involving Ping-pong Ball Toss. The only explaination that could logically explain this shift is that thirteen factors are too many to rotate. That is, no physical meaning can be attached to the latter factor in view of the original loadings for the practice sessions on the eight factor structure. It is interesting to note that this peculiarity would not have been detected had only one or the other of the two solutions involving the Ping-pong Ball Toss variables been derived. This suggest that one should rotate a preliminary solution more than once including increasing numbers of factors. The final structure could then be determined on the basis of logical soundness of the different structures. This concept was originally proposed by Kaizer. However, his proposal suggested only one rotation be done with all factors included. The present study suggest this may produce flaws in the structure which could not be detected by only one rotation. Thus, the muli-rotation scheme seems best.

FACTOR VII

No.	Variable	FB 8F	PP 8F	FB 10F	PP 13F
2	Figure-8 Duck	.83	.85	.87	.76
1	Dodge Run	.68	.69	.68	.84
21	Block Transfer	.48	.49	.48	.22
6	Soccer Dribble	.38	.27	.11	.08
3	Twist & Touch	-.35	-.44	-.33	-.41
14	Ball Balance	-.31	-.34	-.32	-.26
23	1-ft. Lengthwise Balance Eyes Open	.31	.20	.06	.10
18	Two-foot Tapping	-.29	-.20	-.31	-.02
22	Kinesthetic Sense	.17	.20	.30	.15
	% Contribution	6.31	6.78	6.05	5.83

This factor is predominantly loaded with items involving projecting the body with changing directions emphasized. This factor was hypothesized and substantiated by Jackson and others. The factor is to be distinguished from the previous body projection factor which emphasized power. However, it is interesting to note that the two factors have in common a flexibility trait which serves as a limiting factor to successful performance of the high loading tests for each factor. This factor is defined as Body Projection - Agility Emphasized. Some fluctuation from analysis to analysis is to be noted for this factor. However, the changes do not have the drastic effect noted for previous factors. The factor is thus judged to be quite stable.

FACTOR VIII

No.	Variable	FB 8F	PP 8F	FB 10F	PP 13F
3	Twist & Touch	.63	.45	.64	.60
24	Two-ft. Cross Balance Eyes Open	.72	.61	.78	.78
26	Two-ft. Cross Balance Eyes Closed	.60	.52	.52	.28
6	Soccer Dribble	.10	.42	.22	.13
25	1-ft. Lengthwise Balance Eyes Closed	.26	.32	.21	.18
30	Ping-pong B.T. Practice 4		.37		.01
31	Ping-pong B.T. Practice 5		.37		.30
32	Ping-pong B.T. Practice 6		-.16		.27

Variables loading high for this factor and exhibiting robustness across solutions involve tasks requiring balance. This is true both for visual and non-visual cues. Again as with previous factors flexibility appears as a limiting factor to the performance of tasks

loading high on this factor. The justifications given previous ar. valid here also, thus, they will not be repeated. The observations noted previously concerning number of factors influencing the logical soundness of the factor structure may also be seen with the present factor. The contribution of this factor to the performance of the Ping-pong Ball Toss task changes from a contributing factor to a limiting factor. This of course is not logical and thus, is grounds for rejecting the 13 factor solution as unreliable. It is interesting to note, however, that the top loading items remain robust even for this factor solution. Therefore, this factor is defined as Balance - Visual Perception Emphasized.

FACTOR IX

No.	Variable	FB 10F	PP 13F
6	Soccer Dribble	.74	-.78
23	1-ft. Lengthwise Balance Eyes Open	.70	-.20
11	Vertical Jump	-.38	.47
22	Kinesthetic Sense	-.26	.33

This factor has items loading high which include projecting the body with coordinative movement required by the legs. The fact that the vertical jump test loads high for this factor suggest that the coordinative movement is more easily controlled when great strength and/or speed of movement is present. The factor is thus defined Body Projection - Lower Extremities Emphasized.

FACTOR X

No.	Variable	FB 10F	PP 13F
5	Cable Jump	-.85	-.89
13	Hand Grip	.40	.35
26	Two-ft. Cross Balance Eyes Closed	.37	.22
29	Ping-pong B.T. Practice 3		-.44
30	Ping-pong B.T. Practice 4		-.31

This factor has one item with a high factor loading with the remaining items exhibiting low loadings. Only two additional items show loadings over .30 for the Fli-back Paddle Ball Toss analysis. Two of the latter are practice sessions for the novel skill. This factor appears to be a pure factor with its task specific to the Cable Jump skill. The Cable Jump test has been described previously by Fleishman as a Gross Body Coordination Factor. We see no reason to change the definition here. However, in view of the pure loading for this factor we are adding the restriction "task specific" to its definition. The definition then becomes "Gross Body Coordination Task Specific". It is interesting to note that coordination as a motor ability trait generally requires a clear understanding of the task to be performed and is usually highly specific. Thus, the addendum to Fleishman's definition is well founded.

FACTOR XI

No.	Variable	Loading
21	Block Transfer	-.81
18	Two-foot Tapping	.61
7	Bar Snap	-.32
17	Plate Tapping	.31

FACTOR XII

No.	Variable	Loading
26	2-ft. Cross Balance Eyes Closed	.68
32	Ping-pong Practice 6	-.58
25	1-ft. Lengthwise Balance Eyes Closed	.32
7	Bar Snap	-.31

FACTOR XIII

No.		
23	1-ft. Lengthwise Balance Eyes Open	.86
7	Bar Snap	.30

Factor XI appears to be a factor involving speed of movement extremities emphasized but not total body projection. Since speed of movement is generally considered highly specific it is logical that this factor would appear separate of the previous speed of movement factor isolated. The factor does, however, have upper and lower extremity tasks loading high. This suggest that the two extremities are not independent with regard to speed of movement as concept not generally supported by the professional literature. There is, however, no universal agreement concerning this relationship. The factor appears to be robust and thus is defined as Speed of Movement Extremities Emphasized. Factor XII has high loadings associated with balance items with no visual cues. It is interesting to note that a late practice session for the Ping-pong Ball Toss skill has a moderate loading for this factor. This suggest that during latter stages of practice of a novel skill visual cues become less important as a contributing factor to the performance of the task and non-visual cues become more important, for example, kinesthetic perception.

Factor XIII has only one item loading high namely a static balance task permitting vision. This same test appears previously on a number of factors. This suggests that balance as a factor is multidimensional or factorially complex. This factor appears to be only a manifestation of this multidimensionality. It is thus defined as Static Balance.

Factor Structure of Learning Sequences

Fli-back Paddle Ball. Observing Figure 1, it may be noted that the factor identified as Eye-hand Coordination Test Specific accounts for 90 to 98 percent of the amount of variation in the practice scores for the ten practice sessions. The remaining factors extracted and shown to be robust account for no more than eight percent for any one practice session. Thus, one's motor ability characteristics provide little information relative to likely success on this novel skill.

Since the interrelationships among the ten practice sessions are extremely high beginning with the first sessions it may be concluded that reliable performance scores can be obtained based on one's initial efforts on this test.

The eight factors account for greater than 90 percent of the common factor variance. Thus, no additional factors could be added to the factor solution with the hopes of isolating basic motor and/or cognitive factors which would permit one's ultimate performance level to be predicted.

Ping-pong Ball Toss. Factors contributing to the performance of the Ping-pong ball toss task are graphically displayed in Figure 2. The factorial structure for this task is to be distinguished from that

of the Fli-back paddle ball task. Unlike the latter, this factor does not exhibit a factor unique to its performance until late in the practice session. This means that one's initial performance on the Ping-pong ball toss task is related to his previous experiences with motor tasks but as the practice schedule continues, previous experiences become less important with specific practice becoming the dominant factor contributing to performance. These results also suggest that performance based on early practice sessions are not reliable due to the factorially complex nature of the novel skill. We have observed this to be true for some sport skill tasks but surprisingly not true for others. As a result a number of measurement and evaluation texts discussing sports skill tests point out that specific tests are useful (i.e. reliable) for assessing performance of beginners while others are useful only for assessing more advanced performances. The level of difficulty for the battery items could not explain this phenomenon and thus were forced to turn to other factors as a possible explanation. It would appear that this study has provided at least one solution to the problem. From Figure 1 and 2 we note that reliability of task performance is associated with high contribution from the specific task and low contribution from factors isolated in the study. This demonstrates that low complexity of the factorial structure for the novel skill in question is a necessary condition for high reliability of the novel skill. It does not, however, demonstrate that both a necessary and sufficient condition for high reliability has been established since only an association has been demonstrated. In addition, rigorous reliability date were not assessed for the skill tests studied. Final analysis of the question of reliability and specific validity await both additional exploratory

work and highly controlled experimental studies. It is interesting to note, however, that the present study lays the groundwork for these needed studies. Tremendous savings in data collection has been achieved since the present study has made it possible a great deal of data reduction to be achieved in future studies. That is, since specific factors and their association with the learning curves for the novel skills have been isolated, the number of variables needed to further study these associations has been reduced from 36 to only eight.

Figure 2, depicting the factor structure for the Ping-pong ball toss task, provides a means of analyzing the factor patterns in relation to practice. The results indicate clearly that considerable changes occurred in the factor structure of the Ping-pong ball toss task as practice continued. These changes appear to follow a fairly definite trend. The task's factor structure is more complex initially (showed higher loadings on more factors) than for latter stages of practice. For example, following practice schedule 8 the contribution of the eight isolated factors completely collapses. In addition, from practice schedule 6 on, the contribution of the factor defined as specific to the task increases sharply.

The somewhat lower communality (h^2) for practice stage 1 relative to those of the remaining stages (with the exception of stage 6) suggest the presence of more unexplained variance for the task initially than during the latter stages. This would suggest additional factors associated with the task may be operative. Since the gross motor domain is reasonably represented in the study, the additional factors, if present, must come from fine motor skills

and/or non-motor factors. The results do permit us to conclude that certain "motor" factors become less and less important as contributors to individual differences in performance. At the same time, practice on the task itself becomes the major contributor.

From a practical point of view this latter conclusion is important if it can be generalized. The results suggest that college students possessing low motor ability characteristics are not restricted, at least from the motor sense, from acquiring specific sports skills. The results do suggest that individuals of this type may experience difficulty early in the learning process. Thus, identifying these individuals early in a course is most important to permit the instructor the opportunity to guard against the "failure syndrome" so often seen in the first few stages of practice.

There was also a shift in the nature of the factors contributing variance at early and later stages of practice. Figure 2 provides the following view of the Ping-pong ball toss learning curve:

(1) Individual differences in performance for the first stage of practice is insignificantly related to the task itself. In addition, six of the remaining seven factors also contribute little to explaining individual differences. Flexibility as a limiting factor to task performance was the only factor contributing explained variance to the task performance scores. The remaining was identified as variance (i.e. unreliability) or the fact that additional factors not included in the study are operative. It would appear that flexibility limitations operate to inhibit coordinated

control of muscles of the elbow, forearm and hand in performing the ball toss task. We may speculate that the inhibition operates in the following manner. Since flexibility and strength are related, lack of flexibility produces lower levels of strength available to the performer. Consequently, greater numbers of motor units are necessary to perform the task. Since the task is a novel one, and therefore unlearned, difficulty in controlling this larger number of motor units is encountered. As the task is practiced control of the motor units is transferred from the motor area of the cerebral cortex to the pre-motor area. When this occurs the entire movement is initiated as a single pattern and individual control of specific motor units is no longer necessary. Apparently the transformation takes place prior to practice stage three since contribution of factor four in explaining individual differences collapses at that time while contribution of the factor associated with the task itself increases sharply. Simultaneously, factor six -- Extend Flexibility appears as a contributing factor explaining individual differences in performance. This would suggest that establishing the skill of ball tossing at this point is related to how well the performers can mentally establish the nature of the task thereby grasping a feeling for what is involved and also transferring flexibility from a limiting factor to a contributing factor. This latter concept apparently implies that the

individual must establish the flexibility needed to reduce the number of motor units required down to a minimum before high levels of performance can be achieved. Thus, at this stage of practice those individuals achieving this mental picture and the necessary reduction in motor units required, perform the task well, while those who do not, exhibit minimal performances.

For practice stage four, the factorial structure becomes maximally complex. It is at this stage that the largest number of factors exhibit significant loadings. Flexibility as a contributing factor continues to explain individual differences in performances while Balance - Visual Perception Emphasized, General Strength with Explosive Components Emphasized, Body Projection with Power, and to a lesser extent Body Projection - Agility Emphasized emerge as contributing factors. It would appear that this stage is characterized as a point where one's experience and success with previous motor task become important. Many individuals during practice stage three scored high performances. How well they continue to progress thus depends upon their ability to live with success. Clearly those who have realized previous success and/or possessed high motor ability continued to progress with the ball tossing task. Those without, either remained at the same plateau or declined. This is further seen from the fact that the contribution of the task itself decreased in its ability to explain individual differences in performance. Its contribution increases sharply

during the next practice session pointing out that great variability in performance exists. This resulted from further increases in top performances while medium and low performers either remained at the same level or reduced in performance.

From a practical point of view it would appear that increasing confidence within each performer is most important at this stage in insuring continued advances in performance levels. Secondarily, the factorial results do suggest that increasing one's motor ability level at this stage would also enhance performance. It is doubtful that this could be achieved except in the very low coordinated individuals since one's basic motor pattern is generally established prior to entering college. However, for these low coordinated individuals, the results do suggest that some remedial work would be beneficial in improving sports skill performance.

During practice stage six the percent contribution of all the factors decreases including the one specific to the task itself. No logical reasons could be found to explain the reductions. It is well documented that learning curves occasionally produce fluctuations which are unexplained.

Following practice stage six the consistent pattern for the learning curve continues the trend established previously. During practice stages seven and eight, three factors among the motor domain contribute to explain individual differences among performances. Apparently these factors continue to represent traits needed to achieve high levels of performance.

It would appear that these three factors (General Strength, Flexibility, and Body Projection with Power) represent the pathways through which the great reduction in the number of motor units, and therefore, control, is achieved to realize high levels of performance. This hypothesis can be tested for validity using electromyographic recordings of the muscles involved in performing the ball toss. The present study permits us to isolate the specific and pertinent measures to include in this proposed experimental study. Thus, a Master Thesis could be conducted to test this hypothesis. Without this present study it would not be possible.

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TABLE 1. Intercorrelation Matrix for Reference Variables

		1	2	3	4	5	6	7	8	9	10	11
1.	Dodge Run	1.00	.59	-.25	.05	.04	.12	-.26	.08	.07	-.24	-.10
2.	Figure-8 Duck		1.00	-.28	.30	-.02	.11	-.00	.12	.08	-.12	.06
3.	Twist & Touch			1.00	.04	.01	-.04	.03	-.24	-.26	-.09	-.03
4.	Toe Touching				1.00	.24	.01	-.03	-.05	-.01	.02	.10
5.	Cable Jump					1.00	-.03	-.03	.09	.13	.22	.00
6.	Soccer Dribble						1.00	.03	-.05	.06	-.12	-.29
7.	Bar Snap							1.00	.08	.01	.44	.23
8.	Pull-ups Limit								1.00	.93	.44	.33
9.	Pull-ups Timed									1.00	.38	.32
10.	Standing Broad Jump										1.00	.56
11.	Vertical Jump											1.00
12.	Arm Pull											
13.	Hand Grip											
14.	Ball Balance											
15.	Visual Reaction Time											
16.	Movement Time											
17.	Plate Tapping											
18.	Two-foot Tapping											
19.	Lateral Bend											
20.	One-foot Tapping											
21.	Block Transfer											
22.	Kinesthetic Sense											
23.	One-foot Lengthwise Balance Eyes Open											
24.	Two-foot Cross Balance Eyes Open											
25.	One-foot Lengthwise Balance Eyes Closed											
26.	Two-foot Cross Balance Eyes Closed											
	Mean	143.	173.	16.	48.	4.	364.	52.	11.	9.	86.	20.
	S.D.	19.	30.	7.	25.	2.	74.	12.	4.	3.	7.	3.

12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
.04	-.11	-.19	.09	.08	-.04	-.06	-.20	.01	.10	.18	.11	.05	-.01	-.01
-.00	.02	-.37	.04	-.04	-.19	-.15	-.09	-.13	.34	.09	.09	.09	-.20	-.07
-.06	-.13	.04	-.04	-.06	-.04	-.06	.04	-.10	-.30	.05	-.12	.23	.05	.19
-.10	-.20	-.11	.11	.12	.06	.31	.16	.11	-.08	.25	-.13	-.15	-.27	.03
-.03	-.26	.15	.03	.09	-.06	.23	.09	.12	.00	.12	-.05	.05	.12	-.18
-.01	-.00	-.12	-.12	-.09	-.20	-.13	-.16	-.22	.15	-.06	.24	.12	-.08	.14
.13	.22	-.03	-.04	-.14	-.01	-.10	.14	-.13	.14	-.20	.08	.04	-.10	-.06
.43	.21	-.13	-.05	-.15	-.05	.02	-.05	-.06	.14	-.12	-.06	.18	.27	.09
.46	.18	-.11	-.09	-.14	-.05	.02	-.08	-.03	.12	-.11	-.04	.13	.26	.08
.20	.21	-.01	-.04	.01	.09	.01	-.04	.07	-.06	-.16	-.14	.04	.04	-.13
.09	.07	.17	.22	.19	.30	.13	.03	.28	-.15	.19	-.12	.08	.06	-.05
1.00	.35	.02	-.09	-.25	.15	-.01	.24	-.03	.20	-.06	.06	.14	.42	.02
	1.00	-.34	-.60	-.68	-.37	-.25	.03	-.54	.23	-.33	.03	.09	.24	.25
		1.00	.50	.49	.60	.37	.39	.59	-.15	.12	-.10	-.04	.16	-.02
			1.00	.85	.69	.35	.05	.82	-.21	.34	-.01	-.05	-.23	-.20
				1.00	.68	.37	.02	.86	-.33	.32	-.04	-.14	-.37	-.33
					1.00	.53	.28	.81	-.49	.23	-.02	-.10	-.05	-.13
						1.00	.26	.55	-.44	.16	.02	-.20	.09	-.11
							1.00	.08	-.02	.04	.00	-.02	.10	-.11
								1.00	-.46	.33	-.12	-.09	-.16	-.25
									1.00	-.18	.04	.03	.13	-.07
										1.00	-.05	-.02	-.11	-.13
											1.00	-.09	-.06	-.00
												1.00	.15	.22
													1.00	.31
														1.00
75.	93.	91.	196.	81.	46.	13.	34.	28.	90.	138.	235.	422.	373.	23.
22.	18.	76.	53.	76.	9.	2.	10.	8.	56.	70.	323.	240.	182.	11.

TABLE 2. Intercorrelation Matrix of Practice Stages for Positive Learning Curve Skills and Reference Variables

		1	2	3	4	5	6	7	8	9	10	11	12	13
27.	Practice 1	.19	.07	-.20	.03	.11	-.09	-.12	.18	.05	-.01	.05	-.11	-.06
28.	Practice 2	.20	.10	-.15	.07	.14	-.09	-.22	.15	.05	-.05	.04	-.08	-.08
29.	Practice 3	.24	.08	-.11	.09	.10	-.12	-.24	.21	.20	-.08	.05	-.11	-.10
30.	Practice 4	.23	.09	-.12	.07	.10	-.15	-.23	.20	.08	-.08	.04	-.09	-.10
31.	Practice 5	.22	.11	-.14	.07	.09	-.12	-.12	.16	.02	-.05	.02	-.12	-.10
32.	Practice 6	.20	.11	-.17	.04	.11	-.15	-.09	.13	-.01	-.04	.02	-.11	-.08
33.	Practice 7	.19	.10	-.18	.03	.11	-.12	-.04	.10	-.03	-.03	.02	-.11	-.06
34.	Practice 8	.16	.08	-.16	.02	.15	-.12	-.15	.09	-.02	-.04	.04	.04	-.04
35.	Practice 9	.20	.08	-.18	.03	.13	-.10	-.16	.15	.03	-.03	.04	-.04	-.04
36.	Practice 10	.16	.05	-.13	.00	.14	-.14	-.18	.10	-.01	-.05	.04	-.02	-.05

14	15	16	17	18	19	20	21	22	23	24	25	26
.00	-.14	-.03	.04	.19	.16	-.02	-.00	-.11	-.01	.13	.13	.04
.02	-.15	-.03	.07	.22	.14	-.01	-.02	-.09	-.08	.12	.21	.08
-.02	-.14	-.04	.06	.23	.07	-.02	-.03	-.05	-.09	.06	.26	.15
-.02	-.12	-.02	.07	.20	.10	-.01	-.02	-.08	-.13	.09	.23	.09
-.08	-.11	-.01	.06	.15	.09	-.03	.01	-.08	-.13	.08	.18	.03
-.06	-.09	-.01	.06	.15	.12	-.03	.02	-.07	-.13	.08	.19	.02
-.04	-.10	-.01	.07	.14	.12	-.03	.03	-.09	-.12	.08	.17	.01
.04	-.12	-.04	.11	.23	.17	-.00	.00	-.07	-.14	.13	.27	.05
.01	-.14	-.04	.07	.22	.17	-.01	-.00	-.08	-.10	.14	.23	.07
.07	-.11	-.03	.12	.23	.16	.03	-.02	-.06	-.14	.14	.27	.05

TABLE 3. Intercorrelation Matrix of Practice Stages for Negative Learning Curve Skills and Reference Variables

		1	2	3.	4	5	6	7	8	9	10	11	12	13
37.	Practice 1	-.03	.07	-.02	-.03	.01	-.03	.35	.17	.13	.24	.25	-.12	.06
38.	Practice 2	-.18	-.19	.14	-.02	-.07	-.01	.27	-.10	-.01	.20	.24	-.06	-.07
39.	Practice 3	-.05	-.10	.02	.01	.17	-.10	.00	.11	.07	.09	.03	.03	-.03
40.	Practice 4	-.05	-.25	.09	-.27	.19	-.00	.01	.24	.21	.16	-.11	.27	.17
41.	Practice 5	-.09	-.11	.08	-.15	-.06	.09	.24	.32	.23	.23	-.00	.35	.07
42.	Practice 6	-.13	.05	-.02	-.10	-.05	-.20	.20	.09	-.02	.09	.01	.17	.02
43.	Practice 7	-.09	-.12	.02	-.09	-.02	-.23	.27	.05	-.07	.07	.01	.21	-.03
44.	Practice 8	-.12	-.18	.12	-.17	-.17	-.06	.09	.33	.25	.31	.09	.07	-.01
45.	Practice 9	-.06	-.04	-.06	-.05	-.31	-.02	.15	.22	.10	.19	.09	.23	.04
46.	Practice 10	-.08	-.08	-.15	-.16	-.11	.01	.07	.36	.23	.24	.07	.08	.03

14	15	16	17	18	19	20	21	22	23	24	25	26
.06	.09	-.02	.09	.07	.16	.04	-.02	-.19	-.21	.11	-.06	-.13
.19	.16	.09	.22	.06	.02	.19	-.13	-.14	-.02	-.01	-.08	.01
-.05	-.09	-.09	-.07	.15	.02	-.02	-.07	-.05	-.20	-.01	.09	.06
.32	-.04	-.09	.03	.06	.13	.03	.05	-.29	.07	.11	.41	.14
.02	.02	-.18	.05	-.06	.12	-.06	.08	-.09	-.07	.17	.44	.29
-.10	.06	-.02	.22	.05	.18	-.02	-.05	-.05	-.07	.13	.17	-.07
.30	.13	-.01	.20	.04	.31	.04	.17	-.13	.03	.12	.23	.14
.03	.10	.12	.12	.15	-.06	.09	-.16	-.28	-.24	.04	.09	.06
.05	.22	.08	.27	.14	.03	.15	.07	-.17	-.20	.03	.22	.10
.16	.19	.07	.25	.22	.07	.13	.01	-.21	-.13	.13	.21	.14

TABLE 4. Intercorrelation Matrix of Practice Stages for Positive Learning Curve Skills

		27	28	29	30	31	32	33	34	35	36
27.	Practice 1	1.00	.96	.92	.92	.93	.90	.91	.87	.94	.89
28.	Practice 2		1.00	.96	.97	.95	.93	.93	.94	.98	.95
29.	Practice 3			1.00	.99	.96	.93	.92	.91	.95	.92
30.	Practice 4				1.00	.98	.96	.95	.93	.96	.94
31.	Practice 5					1.00	.99	.98	.93	.95	.93
32.	Practice 6						1.00	.99	.95	.95	.94
33.	Practice 7							1.00	.96	.96	.95
34.	Practice 8								1.00	.97	.99
35.	Practice 9									1.00	.98
36.	Practice 10										1.00
	Mean	10.4	12.0	14.8	19.8	21.9	24.2	32.7	35.6	33.5	40.2
	S.D.	9.0	12.2	17.6	27.1	37.9	47.3	81.1	76.7	55.5	72.9

TABLE 5. Intercorrelation Matrix of Practice Stages for Negative Learning Curve Skills

		37	38	39	40	41	42	43	44	45	46
37.	Practice 1	1.00	.52	.11	.09	.18	.15	.15	.19	.11	.12
38.	Practice 2		1.00	.33	.17	.28	.09	.30	.19	.18	.11
39.	Practice 3			1.00	.23	.30	.15	.39	.30	.29	.30
40.	Practice 4				1.00	.43	.07	.32	.33	.35	.51
41.	Practice 5					1.00	.39	.50	.37	.57	.51
42.	Practice 6						1.00	.35	.18	.36	.36
43.	Practice 7							1.00	.30	.56	.41
44.	Practice 8								1.00	.58	.50
45.	Practice 9									1.00	.78
46.	Practice 10										1.00
	Mean	26.1	30.8	34.8	38.3	40.9	39.5	41.3	45.4	45.2	48.0
	S.D.	8.9	9.0	9.4	8.6	10.3	9.2	9.3	9.6	9.7	8.9

TABLE 6. Rotated Factor Loadings for Positive Learning Curve Skills and Reference Variables[1,2]

		I	II	III	IV	V	VI	VII	VIII	IX	X
1.	Dodge Run	.19	.10	.13	.13	.35	.01	.68	-.01	.14	.06
2.	Figure-8 Duck	.07	-.09	.05	.05	-.05	.19	.87	-.03	.09	.04
3.	Twist & Touch	-.15	-.05	-.29	.00	.02	.18	-.33	.64	-.16	-.04
4.	Toe Touching	.04	.04	-.07	-.05	-.07	.84	.23	-.02	-.04	-.21
5.	Cable Jump	.12	.08	.14	-.07	-.00	.19	-.07	.01	-.01	-.85
6.	Soccer Dribble	-.11	-.11	.00	.13	.04	-.03	.11	.22	.74	-.15
7.	Bar Snap	-.14	-.12	-.03	-.18	-.81	-.05	-.03	.04	.14	.03
8.	Pull-ups Limit	.13	-.06	.90	.05	-.14	-.03	.08	.00	-.02	-.05
9.	Pull-ups Timed	.00	-.06	.93	.05	-.05	.00	.05	-.02	.03	-.10
10.	Standing Broad Jump	-.04	.01	.47	.11	-.69	.04	-.20	-.06	-.18	-.13
11.	Vertical Jump	.03	.28	.40	.01	-.50	.17	.03	.08	-.38	.18
12.	Arm Pull	-.12	-.09	.55	-.59	-.00	-.13	.09	.05	.01	.11
13.	Hand Grip	-.07	-.66	.26	-.23	-.17	-.06	-.05	-.04	-.04	.40
14.	Ball Balance	-.00	.63	-.05	-.43	.04	-.19	-.32	.07	-.04	-.12
15.	Visual Reaction Time	-.13	.90	-.05	-.00	-.04	-.02	.15	-.00	-.02	.00
16.	Movement Time	-.02	.91	-.13	.16	-.04	.01	.05	-.12	-.02	-.09
17.	Plate Tapping	.08	.84	.05	-.25	-.07	.09	-.17	-.06	-.02	.25
18.	Two-foot Tapping	.21	.48	.12	-.24	.11	.48	-.31	-.22	.10	-.06
19.	Lateral Bend	.13	.09	-.15	-.81	-.15	.15	-.08	-.03	-.03	-.05
20.	One-foot Tapping	-.01	.93	.05	-.02	.01	.07	-.09	-.11	-.11	.00
21.	Block Transfer	-.02	-.42	.05	-.22	-.07	-.43	.48	-.13	.05	-.26
22.	Kinesthetic Sense	-.11	.38	-.08	-.05	.23	.32	.30	.13	-.26	-.09
23.	One-foot Lengthwise Balance Eyes Open	-.09	-.01	-.02	-.08	-.01	-.00	.06	-.17	.70	.15
24.	Two-foot Cross Balance Eyes Open	.11	-.02	.15	-.01	-.13	-.21	.16	.78	.03	-.06
25.	One-foot Lengthwise Balance Eyes Closed	.20	-.20	.43	-.41	.32	-.22	-.26	.21	-.11	-.02
26.	Two-foot Cross Balance Eyes Closed	.07	-.24	.17	.03	.24	.16	-.18	.52	.17	-.37
27.	Practice 1	.95	-.00	.03	.01	-.04	-.00	.02	-.03	.06	-.00
28.	Practice 2	.98	-.00	.05	-.02	.06	.04	.01	.01	.01	-.02
29.	Practice 3	.96	-.01	.10	.04	.12	.08	.00	.01	-.02	.01
30.	Practice 4	.98	.01	.07	.03	.09	.03	.03	.00	-.06	.00
31.	Practice 5	.98	-.01	.00	.05	-.00	.01	.07	-.02	-.04	-.01
32.	Practice 6	.98	-.01	-.02	.01	-.03	-.03	.07	-.03	-.06	-.01
33.	Practice 7	.98	-.01	-.05	-.01	-.07	-.04	.06	-.03	-.03	-.01
34.	Practice 8	.97	.00	.00	-.10	.02	-.02	.01	.01	-.05	-.01
35.	Practice 9	.99	-.01	.04	-.06	.02	.00	.03	.01	-.01	-.00
36.	Practice 10	.97	.02	.01	-.10	.05	-.03	-.02	.03	-.06	-.01
	Percent Contribution	27.2	13.5	8.0	4.8	5.2	4.4	6.0	4.3	4.0	3.8

[1]Number of factors determined by Eigen Criterion.
[2]Unrotated factor loadings available upon request.

TABLE 7. Rotated Factor Loadings for Negative Learning Curve Skills and Reference Variables[1,2]

		I	II	III	IV	V	VI	VII	VIII	IX
1.	Dodge Run	-.07	-.08	.04	-.01	.84	-.14	-.02	.02	-.06
2.	Figure-8 Duck	-.08	.07	.09	-.22	.76	-.05	-.06	.02	.08
3.	Twist & Touch	-.00	.06	-.29	.18	-.41	-.05	.02	.60	-.08
4.	Toe Touching	-.08	-.07	-.00	.12	.10	.14	-.07	-.09	-.16
5.	Cable Jump	-.16	-.08	.16	.01	-.03	.11	-.02	.05	-.89
6.	Soccer Dribble	-.01	.08	-.01	-.10	.08	-.12	-.78	.13	.01
7.	Bar Snap	.13	.11	.14	-.32	-.34	.10	-.02	.08	.12
8.	Pull-ups Limit	.22	.10	.88	.00	.14	-.03	-.02	.03	-.06
9.	Pull-ups Timed	.09	.08	.89	.03	.12	-.03	-.08	-.01	-.10
10.	Standing Broad Jump	.12	-.01	.64	-.09	-.41	-.15	.13	-.03	-.09
11.	Vertical Jump	-.09	-.27	.54	-.04	-.13	-.06	.47	.06	.15
12.	Arm Pull	.20	.11	.50	-.12	.01	.42	.13	.11	.07
13.	Hand Grip	-.02	.68	.30	-.03	-.07	.18	.09	-.08	.35
14.	Ball Balance	.03	-.64	-.05	-.06	-.26	.46	.02	-.05	-.12
15.	Visual Reaction Time	.12	-.91	-.03	-.03	.09	-.00	.01	.02	.05
16.	Movement Time	-.02	-.93	-.08	.78	-.00	-.12	-.04	-.09	-.04
17.	Plate Tapping	.15	-.78	.06	.31	-.07	.28	.15	-.02	.20
18.	Two-foot Tapping	.12	-.39	.08	.61	-.02	.33	-.01	-.26	-.16
19.	Lateral Bend	.05	-.06	-.07	.03	-.11	.84	.04	-.01	-.05
20.	One-foot Tapping	.02	-.91	.07	.22	-.03	.05	.12	-.09	-.03
21.	Block Transfer	.07	.30	.07	-.81	.22	.13	-.13	-.16	-.05
22.	Kinesthetic Sense	-.20	-.42	-.07	-.02	.15	-.04	.33	.22	-.11
23.	One-foot Lenghthwise Balance Eyes Open	-.13	.03	-.06	.05	.10	-.01	-.20	-.12	.02
24.	Two-foot Cross Balance Eyes Open	.05	.06	.15	-.08	.13	.04	-.10	.78	-.01
25.	One-foot Lengthwise Balance Eyes Closed	.27	.24	.27	.05	-.00	.35	.22	.18	-.15
26.	Two-foot Cross Balance Eyes Closed	.23	.27	.01	.13	-.01	-.00	-.06	.28	.22
27.	Practice 1	.06	.00	.13	.05	.12	.15	-.05	.09	.01
28.	Practice 2	.23	-.13	-.09	.04	-.15	-.09	.11	.02	-.04
29.	Practice 3	.53	.16	-.07	.15	.03	-.16	.29	-.13	-.44
30.	Practice 4	.46	.03	.19	.04	-.12	.21	-.18	.01	-.31
31.	Practice 5	.73	.08	.18	-.10	-.06	.10	.01	.30	-.05
32.	Practice 6	.48	.06	-.04	.15	.07	.19	.25	.27	.08
33.	Practice 7	.69	-.07	-.15	-.26	-.04	.29	.26	.03	-.08
34.	Practice 8	.62	-.06	.23	.20	-.19	-.21	-.11	-.02	.09
35.	Practice 9	.88	-.13	.11	-.05	-.-1	.03	-.01	-.05	.25
36.	Practice 10	.79	-.13	.23	.09	-.00	.05	-.15	-.05	.08
	Percent Contribution	11.1	13.3	8.7	4.5	5.8	5.2	4.0	4.2	4.4

[1] Number of factors determined by Eigen Criterion.

[2] Unrotated factor loadings available upon request.

X	XI	XII	XIII
-.05	.05	.09	.08
.34	-.05	-.17	.02
.08	-.03	.16	-.08
.86	.01	.09	-.12
.08	.01	-.09	-.00
.11	-.00	.15	.24
.21	-.47	-.31	.30
-.04	.02	-.02	-.07
-.04	.00	.08	-.04
.12	-.28	-.23	.03
.21	-.33	.07	-.01
-.09	.22	.01	.27
-.12	-.08	.07	.08
-.26	-.10	.29	-.08
.06	-.06	-.05	.00
.04	.00	-.12	-.06
-.00	-.07	-.05	.11
.20	-.01	.02	.01
.12	-.09	-.11	-.02
-.01	-.04	.01	-.04
-.05	.07	-.02	-.04
.35	.28	.10	.09
-.13	.03	-.03	.86
-.14	-.07	-.00	-.10
-.35	.21	.32	.04
.08	.05	.68	.06
-.04	-.84	-.16	-.23
-.02	-.78	.17	.14
.09	-.21	.12	-.06
-.48	-.06	.19	.07
-.03	-.09	.09	.17
-.00	.00	-.58	.10
-.05	-.19	.05	.15
-.12	-.12	-.08	-.28
.04	.00	-.03	-.10
-.13	-.01	-.06	-.12
4.7	5.7	3.9	3.6

TABLE 8. Ratated Factor Loadings for Positive Learning Curve Skills and Reference Variables[1,2]

		I	II	III	IV	V	VI	VII	VIII
1.	Dodge Run	.20	.13	.14	.19	.28	.06	.68	.01
2.	Figure-8 Duck	.09	-.05	.04	.12	-.12	.23	.83	-.02
3.	Twist & Touch	-.17	-.05	-.32	-.01	.01	.17	-.35	.63
4.	Toe Touching	.03	.07	-.12	-.01	-.10	.82	.15	-.01
5.	Cable Jump	.10	.03	.15	-.10	.06	.61	-.11	-.14
6.	Soccer Dribble	-.14	-.15	-.05	-.01	.20	-.09	.38	.11
7.	Bar Snap	-.15	-.16	-.07	-.27	-.74	-.12	.02	-.03
8.	Pull-ups Limit	.12	-.07	.88	.09	-.19	.03	.07	.02
9.	Pull-ups Timed	-.00	-.06	.91	.09	-.09	.07	.06	-.01
10.	Standing Broad Jump	-.05	-.03	.43	.09	-.70	.08	-.27	-.10
11.	Vertical Jump	.04	.29	.36	.09	-.62	.11	-.12	.14
12.	Arm Pull	-.12	-.08	.60	-.53	-.04	-.10	.11	.10
13.	Hand Grip	-.07	-.64	.26	-.18	-.19	-.24	-.04	.06
14.	Ball Balance	-.00	.61	-.01	-.46	.07	-.10	-.31	.03
15.	Visual Reaction Time	-.12	.90	-.05	-.01	-.08	.00	.12	-.03
16.	Movement Time	-.02	.91	-.14	.13	-.06	.04	.01	-.17
17.	Plate Tapping	.08	.85	.05	-.25	-.10	-.08	-.17	-.01
18.	Two-foot Tapping	.19	.48	.11	-.25	.15	.36	-.29	-.19
19.	Lateral Bend	.13	.09	-.11	-.80	-.12	.19	-.09	-.02
20.	One-foot Tapping	-.01	.94	.05	-.01	-.03	.06	-.14	-.10
21.	Block Transfer	-.01	-.43	.10	-.20	-.06	-.13	.48	-.21
22.	Kinesthetic Sense	-.10	.42	-.07	.04	.12	.41	.17	.16
23.	One-foot Lengthwise Balance Eyes Open	-.12	-.03	-.05	-.21	.14	-.24	.31	-.19
24.	Two-foot Cross Balance Eyes Open	.10	-.03	.12	-.03	-.16	-.10	.19	.72
25.	One-foot Lengthwise Balance Eyes Closed	.20	-.19	.49	-.36	.30	-.11	-.24	.26
26.	Two-foot Cross Balance Eyes Closed	.05	-.21	.13	.03	.23	-.10	-.08	.60
27.	Practice 1	.95	-.01	.03	-.01	-.03	-.01	.03	-.02
28.	Practice 2	.98	-.00	.05	-.02	.05	.05	.01	.02
29.	Practice 3	.96	-.00	.10	.06	.11	.07	-.02	.04
30.	Practice 4	.98	.01	.08	.05	.07	.05	-.00	.03
31.	Practice 5	.98	-.01	.00	.05	-.01	.03	.03	-.01
32.	Practice 6	.98	-.01	-.02	.02	-.04	.01	.03	-.02
33.	Practice 7	.98	-.02	-.04	-.01	-.07	-.01	.04	-.03
34.	Practice 8	.97	-.00	.01	-.10	.01	.02	-.02	.02
35.	Practice 9	.99	-.01	.05	-.06	.02	.02	.01	.02
36.	Practice 10	.97	.02	.03	-.09	.04	.01	-.04	.04
	Percent Contribution	27.2	13.5	8.0	4.8	5.4	4.8	6.3	4.5

[1]Only statistically significant factors rotated.

[2]Unrotated factor loadings available upon request.

TABLE 9. Rotated Factor Loadings for Negative Learning Curve Skills and Reference Variables[1,2]

		I	II	III	IV	V	VI	VII	VIII
1.	Dodge Run	-.04	-.12	.05	.26	.69	-.12	.03	.16
2.	Figure-8 Duck	-.05	.08	.03	-.05	.85	-.09	.13	-.06
3.	Twist & Touch	-.06	.05	-.30	-.11	-.44	-.03	.23	.45
4.	Toe Touching	-.15	-.10	-.07	-.05	.25	.02	.64	-.15
5.	Cable Jump	-.25	-.11	.18	.01	.02	.29	.51	.19
6.	Soccer Dribble	-.10	.08	-.06	.02	.27	-.19	-.29	.42
7.	Bar Snap	.10	.17	.05	-.73	-.00	.20	-.16	-.10
8.	Pull-ups Limit	.22	.07	.88	-.02	.15	-.03	.06	.08
9.	Pull-ups Timed	.08	.05	.89	.00	.12	-.05	.04	.12
10.	Standing Broad Jump	.09	.03	.60	-.50	-.21	-.05	.08	-.15
11.	Vertical Jump	-.09	-.25	.50	-.46	-.09	-.02	.18	-.13
12.	Arm Pull	.17	.10	.51	.09	.07	.51	.16	.04
13.	Hand Grip	.04	.67	.31	-.05	-.12	.13	-.23	-.11
14.	Ball Balance	.01	-.65	-.03	-.03	-.34	.42	-.13	.13
15.	Visual Reaction Time	.10	-.89	-.06	-.12	.15	-.03	-.03	-.03
16.	Movement Time	-.03	-.91	-.09	-.05	.03	-.16	.00	-.14
17.	Plate Tapping	.16	-.83	.05	-.08	-.16	.18	-.06	-.16
18.	Two-foot Tapping	.12	-.52	.10	.15	-.20	.17	.33	-.20
19.	Lateral Bend	.07	-.11	-.09	-.12	-.10	.73	.12	-.15
20.	One-foot Tapping	.02	-.93	.07	-.03	-.10	-.01	.07	-.12
21.	Block Transfer	.05	.42	.05	-.04	.49	.24	-.25	-.02
22.	Kinesthetic Sense	-.27	-.40	-.08	.15	.20	.08	.35	.02
23.	One-foot Lengthwise Balance Eyes Open	-.21	-.01	-.07	.05	.20	.20	-.47	.05
24.	Two-foot Cross Balance Eyes Open	.03	.07	.12	-.16	.11	.04	.02	.61
25.	One-foot Lengthwise Balance Eyes Closed	.26	.18	.34	.31	-.20	.44	-.00	.32
26.	Two-foot Cross Balance Eyes Closed	.17	.23	.02	.19	-.14	-.06	-.00	.52
27.	Practice 1	.15	-.03	.08	-.70	.04	-.03	.09	.08
28.	Practice 2	.23	-.15	-.12	-.65	-.20	-.04	.02	.20
29.	Practice 3	.51	.10	-.03	-.05	-.10	-.02	.47	.08
30.	Practice 4	.43	-.03	.24	.09	-.24	.28	-.18	.37
31.	Practice 5	.66	.08	.17	-.15	.00	.22	-.02	.37
32.	Practice 6	.52	.03	-.06	-.16	.08	.24	.09	-.16
33.	Practice 7	.66	-.06	-.15	-.21	.01	.45	-.01	.10
34.	Practice 8	.65	-.08	.24	-.10	-.26	-.33	-.00	.03
35.	Practice 9	.89	-.13	.10	-.04	.03	-.03	-.09	-.04
36.	Practice 10	.80	-.16	.23	.03	-.03	-.03	-.09	.05
	Percent Contribution	11.1	13.9	8.6	6.5	6.8	5.7	5.1	5.0

[1] Only statistically significant factors rotated.

[2] Unrotated factor loadings available upon request.

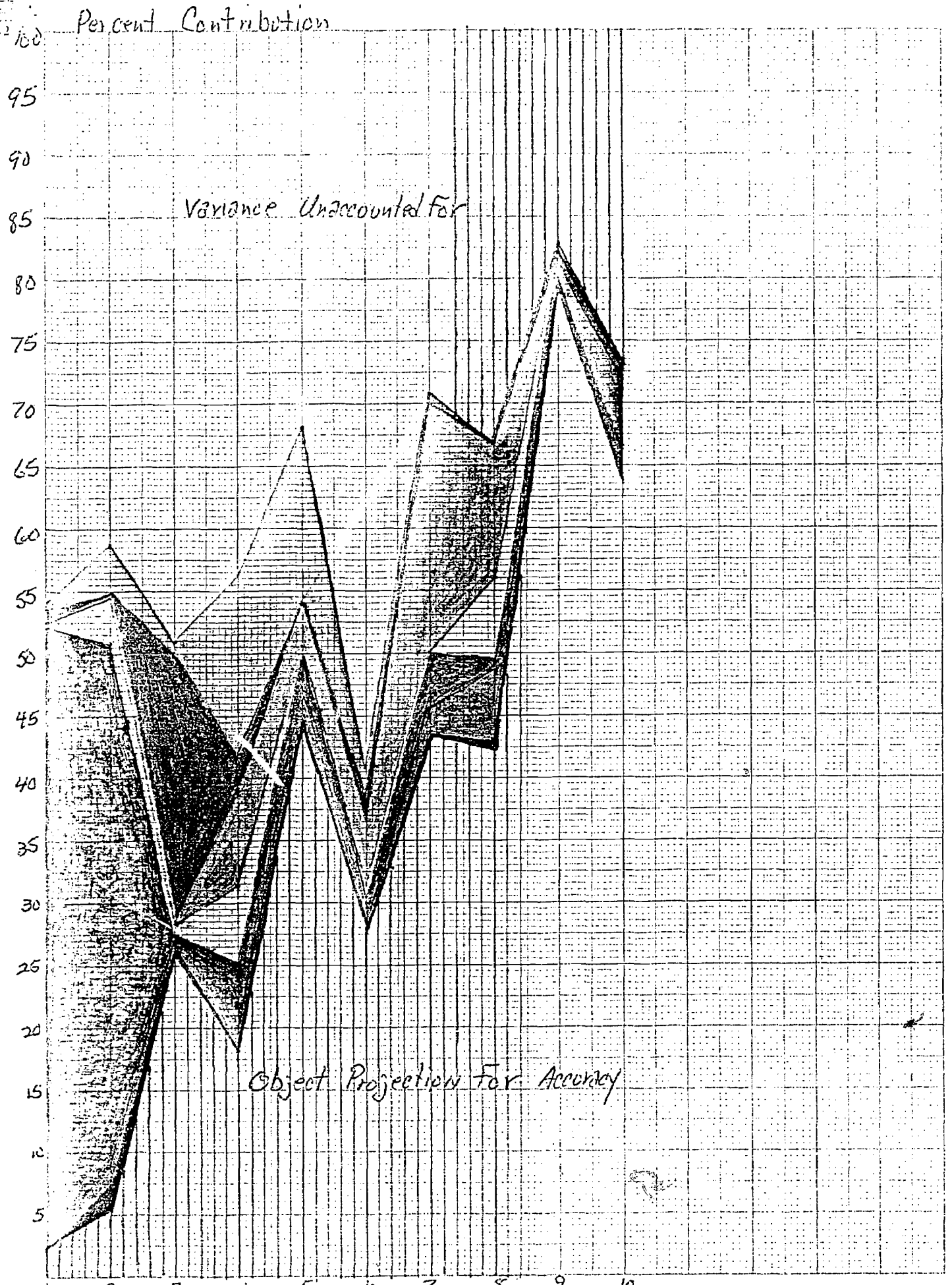

Figure 2. Stages of Practice on Ping-Pong Ball Toss

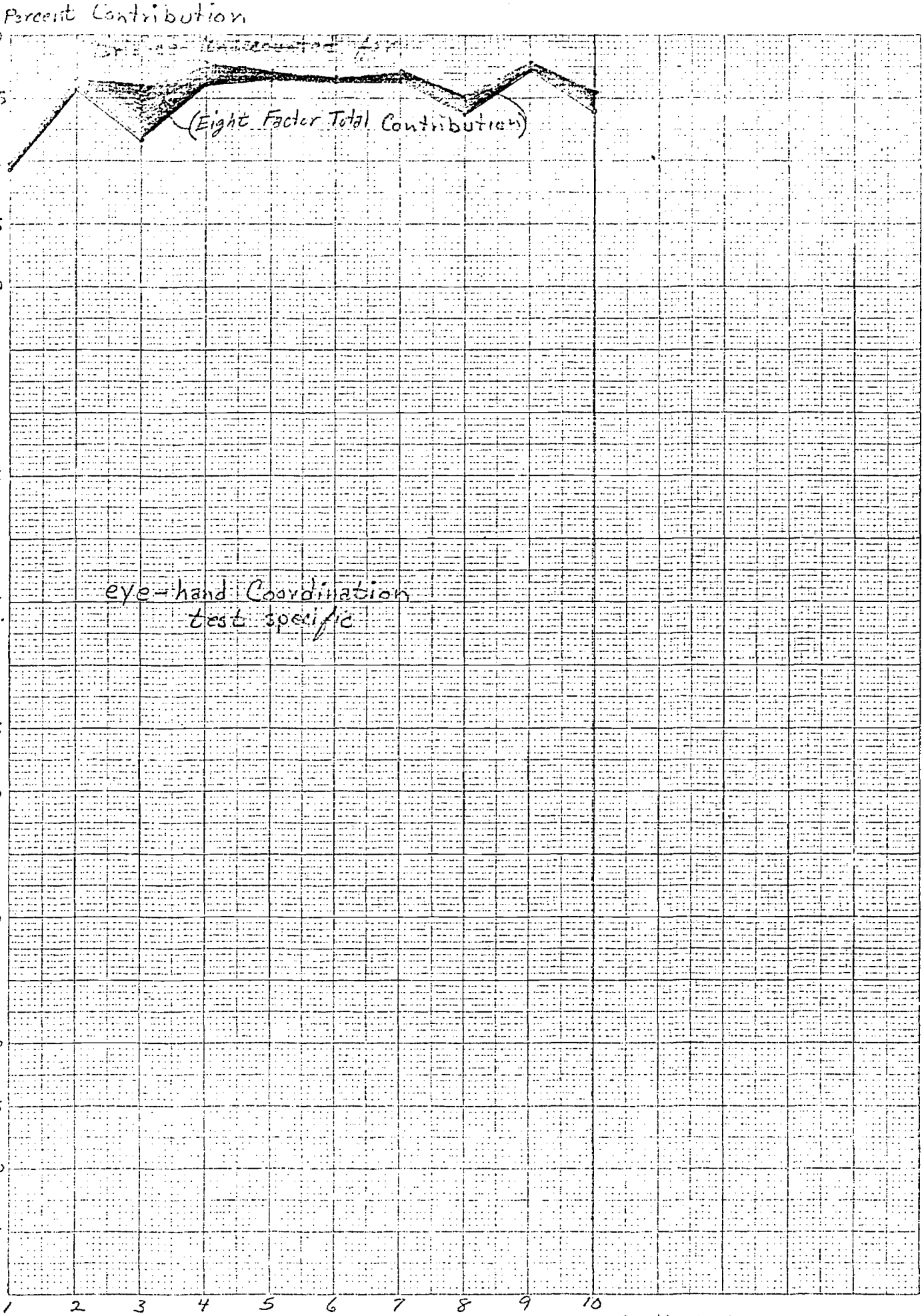

Figure 1. Stages of Practice on Fli-Back Paddle Ball